MULTI STEP COAT

FIELD OF THE INVENTION

The present invention pertains to a resist material deposition method on Si wafer or another semiconductor substrate for use in semiconductor devices.

BACKGROUND OF THE INVENTION

Usually, in the manufacturing process of semiconductor devices, there is a processing step in which the resist is deposited as a photomask for exposure on Si or another semiconductor substrate. In this processing step, for example, in the case of an 8-in Si wafer, the resist material is deposited as shown in FIGS. 5 and 6.

As shown in graph a in FIG. 5, first the semiconductor substrate 102 is rotated at a constant velocity of 1500 rpm. As shown in graph b, about 1 sec after the start of rotation, feeding of resist material 103 to the central portion of semiconductor substrate 102 is initiated (FIG. 6(a).

As resist material 103 is fed while semiconductor substrate 102 is rotated at the velocity for about 4 sec, resist material 103 spreads toward the circumferential portion of semiconductor substrate 102 as shown in FIGS. 6(b)-(d).

Then, as the supply of resist material 103 is stopped, the rotational velocity of semiconductor substrate 102 is raised to 3500 rpm, and the resist film is deposited.

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By using this method, it is possible to form a resist film with a nearly uniform film thickness on semiconductor substrate 102.

However, in the conventional deposition method, in order to deposit resist material 103 over the entire surface of semiconductor substrate 102 without any unevenness, a significant amount of resist material 103 is required. As a result, the manufacturing cost of the semiconductor devices increases.

On the other hand, if the amount of resist material 103 supplied is reduced in the aforementioned conventional method, the resist material may be applied unevenly, making reliable deposition impossible. This is a disadvantage.

The purpose of the present invention is to solve the aforementioned problems of the conventional methods by providing a resist material deposition method which enables reliable deposition with a small amount of resist material, free of unevenness.

SUMMARY OF INVENTION

In order to realize the aforementioned purpose, the ~~invention of Claim 1 provides a resist material deposition method~~ characterized by the fact that it comprises the ~~following~~ processing steps: a first processing ~~step~~ in which the resist material is fed to the central portion of the semiconductor substrate, and ~~a second~~ processing step in which the aforementioned semiconductor substrate is rotated at a high ~~velocity so~~ that the aforementioned ~~resist material is spread~~

smoothly toward the circumferential portion of the aforementioned semiconductor substrate.

The invention of Claim 2 provides the resist material deposition method described in Claim 1, characterized by the fact that in the second processing step, the semiconductor substrate is rotated at a velocity of 3000 rpm or higher, preferably 3000-3800 rpm.

The invention of Claim 3 provides the resist material deposition method described in Claim 2, characterized by the fact that the semiconductor substrate is not rotated in the first processing step.

The invention of Claim 4 provides the resist material deposition method described in Claim 2, characterized by the fact that in the first processing step, the semiconductor substrate is rotated at a velocity in the range of 1000-1500 rpm.

According to the invention of Claim 1, the resist material fed to the central portion of the semiconductor substrate in the first processing step can spread smoothly to the circumferential portion of the substrate in the second processing step when the semiconductor substrate is rotated at high velocity. Consequently, even a small amount of resist material can be deposited over the entire surface of the semiconductor substrate without unevenness.

In this case, according to the invention described in Claim 2, the semiconductor substrate is rotated at 3000 rpm or more in the second processing step. In this way, it is possible to deposit the resist material more reliably over the entire surface of the semiconductor substrate.

~~On the other hand, according to the~~ invention described ~~in~~ Claim 3, the semiconductor substrate is not rotated in the first processing step, and, according to Claim 4, the semiconductor substrate is rotated at a velocity in the range of 1000-1500 rpm in the first processing step. In both cases, the semiconductor substrate is rotated at a velocity of 3000 rpm or more in the second processing step, so that the resist material is deposited over the entire surface of the semiconductor substrate more ~~reliably.~~

In the following, the resist material deposition method of the present invention will be explained in more detail with reference to embodiments illustrated in the FIGS.

FIG. 4 is a diagram schematically illustrating the constitution of the resist material deposition device of an embodiment of the present invention.

This device is set inside a container (not shown in the FIG.) that can maintain the prescribed temperature and humidity.

As shown in FIG. 4, this device has chuck 1 which can be rotated at the prescribed rotational velocity by a motor or other rotary driving source not shown in the FIG. Si wafer or another semiconductor substrate 2 is mounted in said chuck 1. A resist material 3 is fed from a nozzle on the end of arm 4 and deposited on semiconductor substrate 2. The arm is arranged such that it can move in the radial direction of semiconductor substrate 2 from the center of rotation of semiconductor substrate 2 to any given position above semiconductor substrate 2. In addition, a receiving portion 5 is arranged on the circumference of

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semiconductor substrate 2 for receiving the resist material 3 that spins off during rotation of semiconductor substrate 2.

Also, filter 6 for removing dust from the room is arranged to remove dust from the chamber. Also, although not shown in the FIG., an arm for feeding the detergent solution for washing the edge of semiconductor substrate 2 is also arranged.

Also, when this device is used to deposit resist material 3, for example, the temperature of resist material 3 and the ambient temperature are maintained at room temperature (about 23°C) and the humidity at about 41%.

In the following, a preferred embodiment of the resist material deposition method in the present invention will be explained.

FIG. 1 is a graph illustrating the relationship between the rotational velocity of semiconductor substrate 2 and the deposition time of the resist material. FIG. 2 is an enlarged view of the main portion of FIG. 1.

In FIGS. 1 and 2, the case of depositing resist material on an 8-inch semiconductor substrate 2 is illustrated. Graph A indicates the rotational velocity of semiconductor substrate 2, and graph B indicates the coating time of resist material 3.

As shown in FIGS. 1 and 2, first, semiconductor substrate 2 is rotated at a low velocity (about 1500 rpm) for about 1 sec so as to remove dust, etc., adhered to semiconductor substrate 2. In this processing step, resist material 3 is not ejected as arm 4 is moved to the central portion of semiconductor substrate 2.

Then, the rotational velocity of semiconductor substrate 2 is reduced, and the rotation finally halted. Resist material 3 is then fed from the end of arm 4 at a prescribed rate (about 0.9 cm^3/sec) to the central portion of semiconductor substrate 2.

As a result, resist material 3 accumulates at the central portion of semiconductor substrate 2 as shown in FIG. 3(a).

Then, while the feeding of resist material 3 continues, after about 1.8 sec from the start of operation, semiconductor substrate 2 begins to be rotated at a high velocity (about 3000-3800 rpm) for about 1 sec.

As a result, as shown in FIG. 3(b), resist material 3 spreads toward the circumferential portion of semiconductor substrate 2. In addition, as shown in FIG. 3(c), resist material 3 is deposited smoothly on almost the entire surface up to the circumferential portion of semiconductor substrate 2.

Also, when semiconductor substrate 2 is rotated at a velocity of 4000 rpm or more, spun resist material 3 may bounce back from receiving portion 5 and the flatness of the resist film may deteriorate.

Then, the feeding of resist material 3 continues, while the rotational velocity of semiconductor substrate 2 is reduced (to about 800 rpm) and rotation is carried out for about 0.4 sec. Then, the feeding of resist material 3 is stopped after about 3.2 sec from the start of the process. In this way, as shown in FIG. 3(d), resist material 3 is deposited over the entire surface of semiconductor substrate 2.

Then, as shown in FIG. 1, after semiconductor substrate 2 is rotated at a low velocity (about 800 rpm) for awhile, the

rotational velocity of semiconductor substrate 2 is raised (to about 2900 rpm), and the thickness of the resist film is adjusted.

As explained in the above, in this embodiment, the semiconductor substrate is rotated at a high velocity of about 3000-3800 rpm so that the resist material 3 fed to the central portion of semiconductor substrate 2 when it is stopped will spread out smoothly towards the circumferential portion. Consequently, even a small amount of resist material can be deposited over the entire surface of semiconductor substrate 2 without unevenness.

Consequently, in this embodiment, it is possible to reduce the deposition amount of resist material 3 significantly (to about 1/3 that of the aforementioned conventional method), and it is possible to cut the cost of the manufacturing process of the semiconductor device significantly.

The present invention is not limited to the aforementioned embodiment, and various changes can be made.

For example, there is no limitation on the size of the semiconductor substrate to which the present invention can be applied. For example, in addition to 8-in semiconductor substrates, the present invention may also be applied to 5-in semiconductor substrates, 6-in semiconductor substrates, etc.

Also, various types of resist materials may be used, that is, both positive and negative type resist materials as well as various photoresists, resists for electron beam use, etc., can be used.

In the aforementioned embodiment, the resist material is fed when the semiconductor substrate is stopped. However, the present invention is not limited to this case. For example, it is possible to start feeding of the resist material while the semiconductor substrate is rotated at a low velocity (about 1000-1500 rpm), and the resist material is then fed while the velocity of the semiconductor substrate is raised to a high velocity (about 3000-3800 rpm).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram illustrating the relationship between the rotational velocity of the semiconductor substrate and the deposition time of the resist material in a preferred embodiment of the present invention.

FIG. 2 is an enlarged view of the main portion of FIG. 1.

FIG. 3(a), 3(b), 3(c) and (d) illustrates schematically the deposition process of the resist material in this embodiment.

FIG. 4 is a schematic diagram illustrating the constitution of the resist material coating device used in the embodiment of the present invention.

FIG. 5 is a diagram illustrating the relationship between the rotational velocity of the semiconductor substrate and the deposition time of the resist material.

FIG. 6(a)-(d) illustrates schematically the deposition process of the resist material of the prior art.

DESCRIPTION OF EMBODIMENTS

In the following, the present invention will be explained in more detail with reference to embodiments and comparative examples.

Embodiment 1

Using a deposition device TEL MK-8 manufactured by Tokyo Electron Co. Ltd., a resist material was deposited on an 8-in-diameter semiconductor substrate.

In this case, as the resist material, a solution prepared by dissolving IP3100 (viscosity of 9 cP) mainly made of novolac resin and manufactured by Tokyo Oka Kogyo K.K. in MMP (methyl-3-methoxypropionate) as the solvent was used. The resist material was deposited in the order given in Table I. Also, in this table, O indicates feeding of the resist material.

As listed in Table I, first the semiconductor substrate was rotated at 1500 rpm for 1.0 sec (step 1) to remove dust adhered to the semiconductor substrate. The rotational velocity of the semiconductor substrate was then reduced and the rotation was

finally stopped. Then, feeding of the resist material to the central portion of the semiconductor substrate was started (step 2).

Then, after 0.8 sec, the semiconductor substrate was rotated at 3700 rpm for 1.0 sec (step 3). Then, as feeding of the resist material was continued, the rotational velocity of the semiconductor substrate was reduced to 800 rpm, at which velocity the semiconductor substrate was rotated for about 0.4 sec. 3.2 sec after the start of the operation, feeding of the resist material was stopped (step 4).

After the semiconductor substrate was rotated at 800 rpm for 1.0 sec (step 5), the rotational velocity of the semiconductor substrate was raised to 2940 rpm and the thickness of the resist film was adjusted (step 6).

Table I

In Embodiment 1, 2.0 cm^3 of resist material was used to form a 1.03-µm-thick resist film on the semiconductor substrate.

<u>Comparative Example 1</u>

The same device and resist material as those used in Embodiment 1 were used to deposit the resist material on an 8-in-diameter semiconductor substrate in the order given in Table II.

As listed in Table II, first the semiconductor substrate was rotated at 1500 rpm for 1.0 sec (step 1) to remove the dust

adhered to the semiconductor substrate. Then, as the semiconductor substrate was rotated at the same rotational velocity, the resist material was fed for 4.0 sec to the central portion of the semiconductor substrate. Then, feeding of the resist material was stopped (step 2).

Then, the rotational velocity of the semiconductor substrate was reduced to 800 rpm and the semiconductor substrate was rotated for 1.0 sec. Then, the rotational velocity was raised to 2940 rpm to adjust the thickness of the resist film (step 4).

Table II

In the case of Comparative Example 1, in order to ensure that no unevenness takes place, it is necessary to use 8 cm^3 of resist material.

<u>Embodiment 2</u>

Resist material was deposited on a 6-in-diameter semiconductor substrate with deposition device TEL MK-5 manufactured by Tokyo Electron Co. Ltd.

In this case, as the resist material, a solution prepared by dissolving PFI-34A (viscosity of 9 cP) mainly made of novolac resin and manufactured by Sumitomo Chemical Co. Ltd. in MAK (methyl-n-amylketone-2-heptanone) as the solvent was used. The resist material was deposited in the order given in Table III.

As listed in Table III, first the semiconductor substrate was rotated at 1000 rpm for 20.0 sec (step 1). Then, the

rotational velocity of the semiconductor substrate was reduced and the rotation was finally stopped. Then, feeding of the resist material to the central portion of the semiconductor substrate was started (step 2).

Then, after 0.3 sec, the semiconductor substrate was rotated at 3000 rpm for 0.4 sec (step 3). Then, as feeding of the resist material was continued, the rotational velocity of the semiconductor substrate was reduced to 1500 rpm, at which velocity the semiconductor substrate was rotated for about 0.3 sec. 21.0 sec after the start of the operation, the feeding of the resist material was stopped (step 4).

After the semiconductor substrate was rotated at 1000 rpm for 0.3 sec (step 5), the rotational velocity of the semiconductor substrate was raised to 2010 rpm and the thickness of the resist film was adjusted (step 6).

Table III

In Embodiment 2, by using 1.0 cm^3 of the resist material, a 1.45-μm-thick resist film was formed on the semiconductor substrate.

<u>Comparative Example 2</u>

The same device and resist material as those used in Embodiment 2 were used to deposit the resist material on a 6-in-diameter semiconductor substrate in the order given in

Table IV.

As listed in Table IV, first the semiconductor substrate was rotated at 1000 rpm for 1.0 sec (step 1). Then, as the semiconductor substrate was rotated at this rotational velocity, the resist material was fed for 2.5 sec to the central portion of the semiconductor substrate. Then, feeding of the resist material was stopped (step 2).

The semiconductor substrate was then rotated at 1500 rpm for 0.3 sec (step 3). Then, the rotational velocity was raised to 2030 rpm to adjust the thickness of the resist film (step 4).

Table IV

In the case of Comparative Example 2, in order to ensure that no coating unevenness takes place, it is necessary to use 3 cm^3 of resist material.

Embodiment 3

Using the same device as that used in Embodiment 2, resist material was coated on a 5-in-diameter semiconductor substrate.

In this case, as the resist material, a solution prepared by dissolving PF-D30B (viscosity of 28 cP) mainly made of novolac resin and manufactured by Sumitomo Chemical Co. Ltd. in MAK as the solvent was used. The resist material was deposited in the order given in Table V.

As listed in Table V, first the semiconductor substrate was rotated at 700 rpm for 20.0 sec (step 1). The rotational velocity

of the semiconductor substrate was then lowered and the rotation finally stopped. Then, feeding of the resist material to the central portion of the semiconductor substrate was started (step 2).

Then, after 0.2 sec, the semiconductor substrate was rotated at 3000 rpm for 0.3 sec (step 3). Then, while feeding of the resist material was continued, the rotational velocity of the semiconductor substrate was lowered to 1500 rpm, at which velocity the semiconductor substrate was rotated for about 0.2 sec. 20.7 sec after the start of the operation, feeding of the resist material was stopped (step 4).

After the semiconductor substrate was rotated at 1500 rpm for 4.0 sec (step 5), the rotational velocity of the semiconductor substrate was raised to 4610 rpm (step 6), and then the thickness of the resist film was then adjusted (step 7).

Table V

In Embodiment 3, by using 0.7 cm^3 of resist material, a 1.85-μm-thick resist film was formed on the semiconductor substrate.

<u>Comparative Example 3</u>

The same device and resist material as those used in Embodiment 3 were used to deposit the resist material on a 5-in-diameter semiconductor substrate in the order given in Table VI.

As listed in Table VI, first the semiconductor substrate was rotated at 700 rpm for 2.0 sec (step 1). After the rotational velocity of the semiconductor substrate was raised to 1500 rpm, the resist material was then fed for 6.0 sec to the central portion of the semiconductor substrate for deposition. Then, feeding of the resist material was stopped (step 2).

The semiconductor substrate was then rotated at 1500 rpm for 0.5 sec (step 3). The rotational velocity was then raised to 4800 rpm (step 4), and the thickness of the resist film was adjusted (step 5).

Table VI

In the case of Comparative Example 3, in order to ensure that no unevenness takes place, it is necessary to use 3 cm^3 of resist material.

As described above, according to the invention of Claim 1, the resist material fed to the central portion of the semiconductor substrate in the first processing step spreads out smoothly toward the circumferential portion of the semiconductor substrate in the second processing step as the semiconductor substrate is rotated at high velocity. Consequently, even a small amount of resist material can be deposited over the entire surface of the semiconductor substrate without unevenness.

In this case, according to the invention of Claim 2, as the semiconductor substrate is rotated at a velocity of 3000 rpm or more in the second processing step, the resist material can be